Chapter 10

Construction

Tentative bridge sites are selected through reconnaissance, and the more promising sites are reconnoitered in detail. The selection of a bridge site is governed by both tactical and technical considerations. Tactical requirements govern the general area for the bridge site. Technical considerations govern the site for permanent construction. A preliminary reconnaissance is made at the best site to establish horizontal and vertical control and to obtain information for the bridge design and construction planning. For bridge construction to proceed, it is necessary to locate a site, obtain information for design, and determine lines and grades for construction. The accuracy of measurements and the number and type of survey markers will vary depending on the degree of precision demanded and the type of construction to be performed.

PLANNING PROCESS

10-1. A systematic approach is needed to construct a bridge efficiently. Use the process described below when planning bridge construction.

BRIDGE-SITE INVESTIGATION

10-2. The characteristics of the gap will determine many of a bridge's requirements (such as length, materials, and construction time and effort). Reconnaissance and preliminary investigation requirements are discussed in *Chapter 2*. Construction in extremely cold environments is discussed in *TM 5-852-1*.

BRIDGE CONFIGURATION

10-3. Steel construction is preferred but requires special equipment, which may not be available. Timber may be readily available but is not capable of supporting the long spans that steel can accommodate. *Chapters 6* and *7* discuss specific information for determining a bridge configuration. The two major elements to consider are the—

- **Superstructure.** Choose a superstructure that will minimize the construction effort and provide the needed capacity. Rely on simply supported stringer bridges as much as possible to take advantage of their design and construction ease. Keep economy in mind when designing the superstructure.
- **Substructure.** Choose a substructure that will also minimize the construction effort. To design the substructure properly, assume the loads on the substructure and then verify these loads before completing the final design. The characteristics of the gap (wet or dry) will affect the type of substructure necessary.

WORKING DRAWINGS

10-4. After determining the bridge's configuration, prepare the necessary drawings. Preparation of complete drawings is necessary when AFCS standard designs are not suited to the conditions at the construction site. Try to adapt standard designs to construction requirements. Do not initiate detailed drawings until the subsurface conditions have been thoroughly explored. Final design decisions are affected by the limitations of the site, the available materials, the equipment, the labor, and the available time. Ensure that all drawings are accurately scaled. Scale detailed and cross-sectional views to show the required information. See *FM 5-233* for more information about bridge drawings. The drawings discussed below are required.

Elevation

10-5. A complete profile of the bridge will be needed. This view shows the elevations of the entire structure and bridge site in skeleton form. The drawing also serves as a record of the substructure analysis *(Figure 10-1)*.

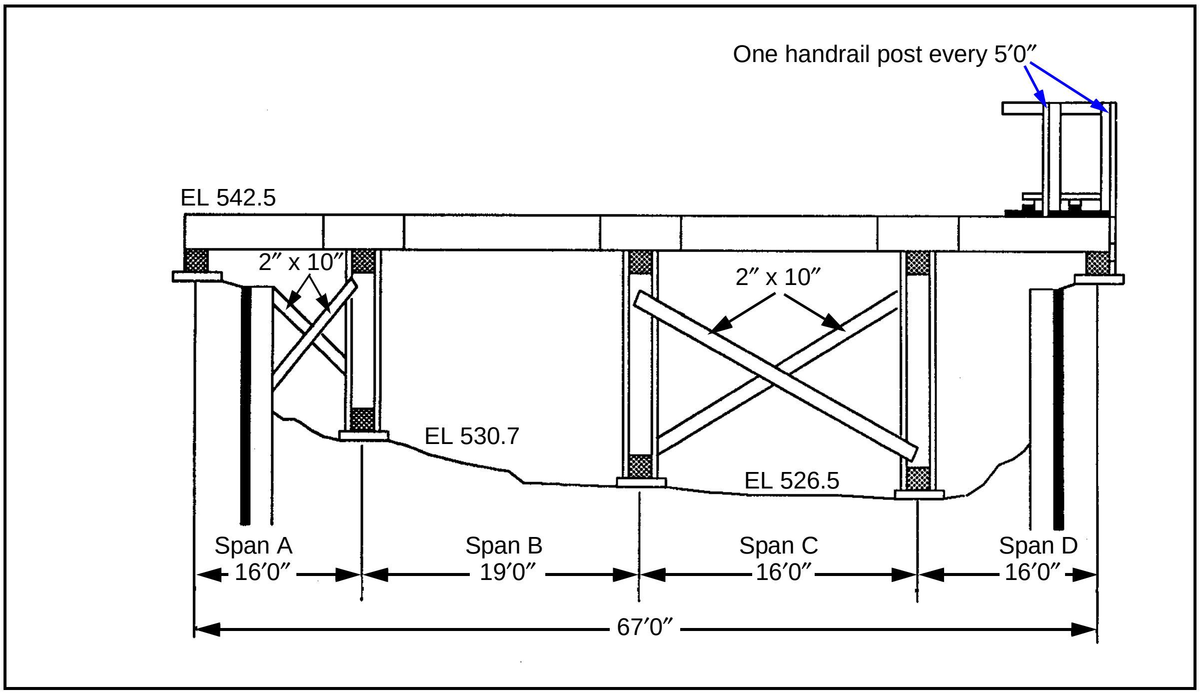


Figure 10-1. Elevation Drawing

Plan

10-6. A complete overhead view of the bridge will also be needed. This view shows the horizontal plan of the entire structure *(Figure 10-2)*. The plan includes all overhead view details (span lengths, pier and abutment locations, stringer placement, centerline, component identifications, and so forth). The plan also notes piece marks of all structural members that require a more detailed drawing and indicates their location. Plans for steel bridges identify the fixed and expansion ends of the structure.

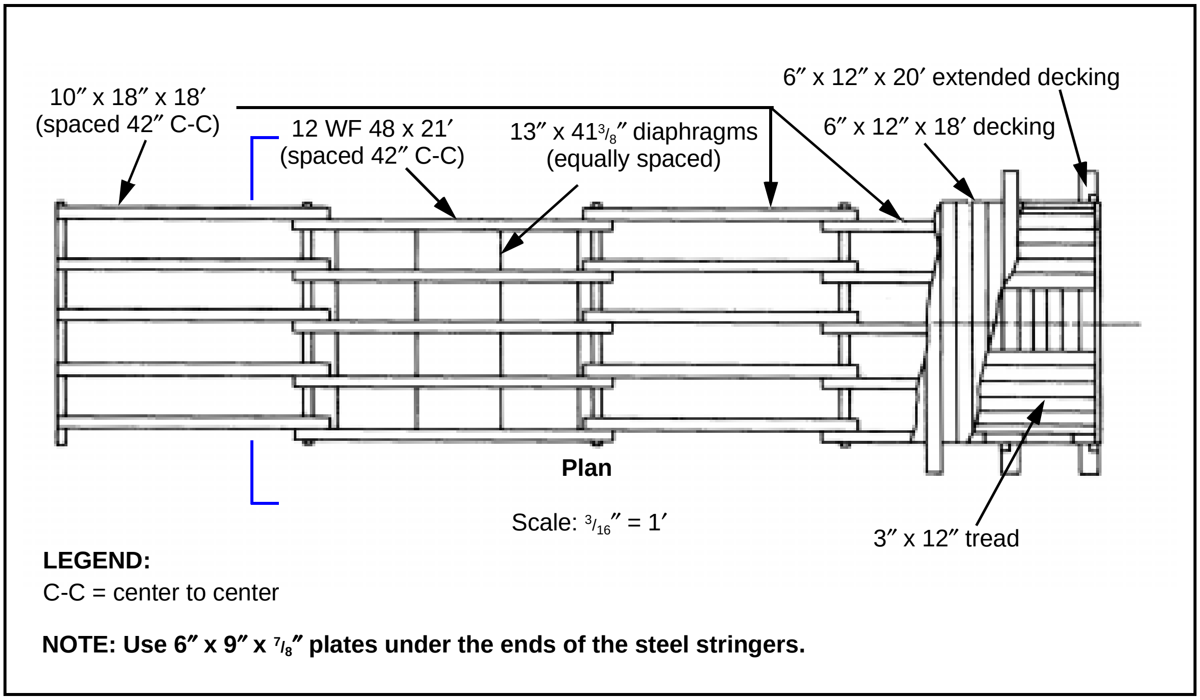


Figure 10-2. Plan Drawing

Foundation

10-7. The foundation plan shows the outline and location of all pier and abutment footings. The survey shows the station number of each footing at the centerline or reference line. Contour lines indicate the lay of the land and outline the banks and other terrain features *(Figure 10-3)*.

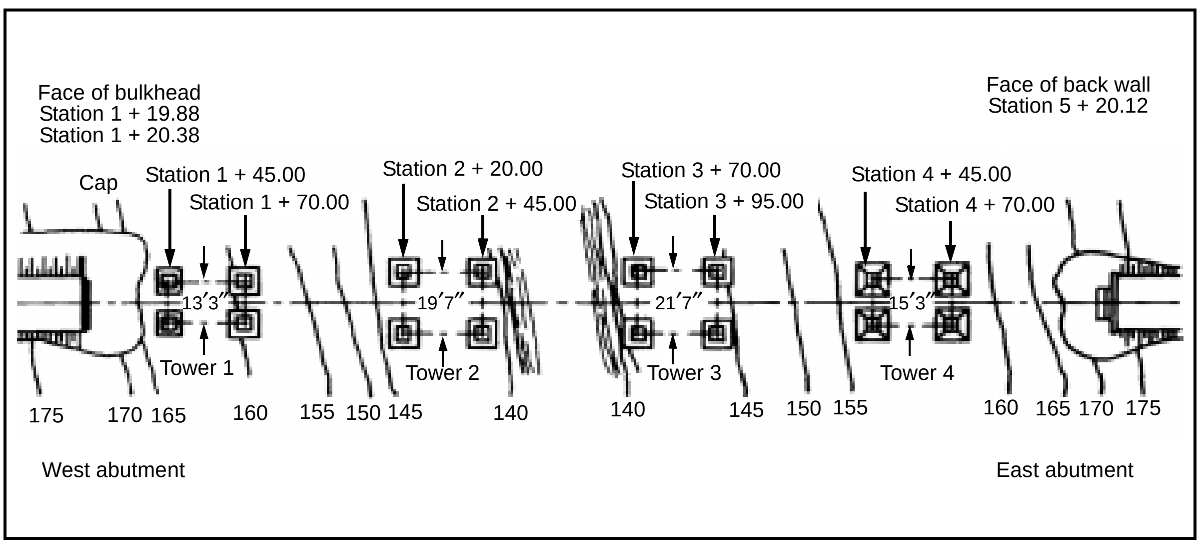


Figure 10-3. Foundation Drawing

Detailed and Cross-Sectional Views

10-8. Detailed drawings and cross-sectional views show how to fabricate or place the parts. Detailed drawings show all the dimensions to the nearest 1/16 inch, the location and size of the connection holes, the details of the connecting parts, and the piece mark. Detailed drawings may also include the construction methods and notes on detail when these are not covered by separate specifications. The cross-sectional views give the overall width of the roadway and any other important dimensions that are constant *(Figure 10-4)*. Cross-sectional views are required when variations in dimensions occur along the length of the bridge.

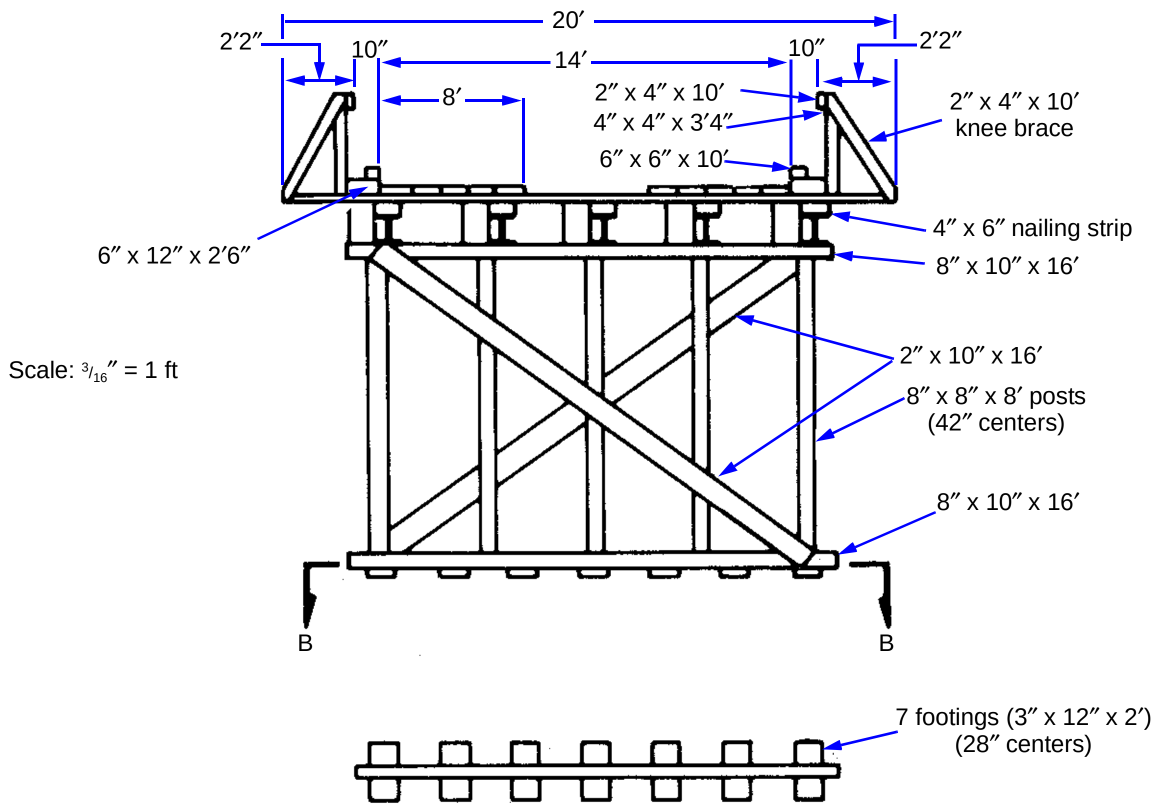


Figure 10-4. Cross-Sectional Drawing

Assembled Views

10-9. Assembled views (commonly called erection plans) show the relationship of the various parts. These drawings include details about how the parts fit together, the process of assembling, and the piece marks of the parts involved *(Figure 10-5)*.

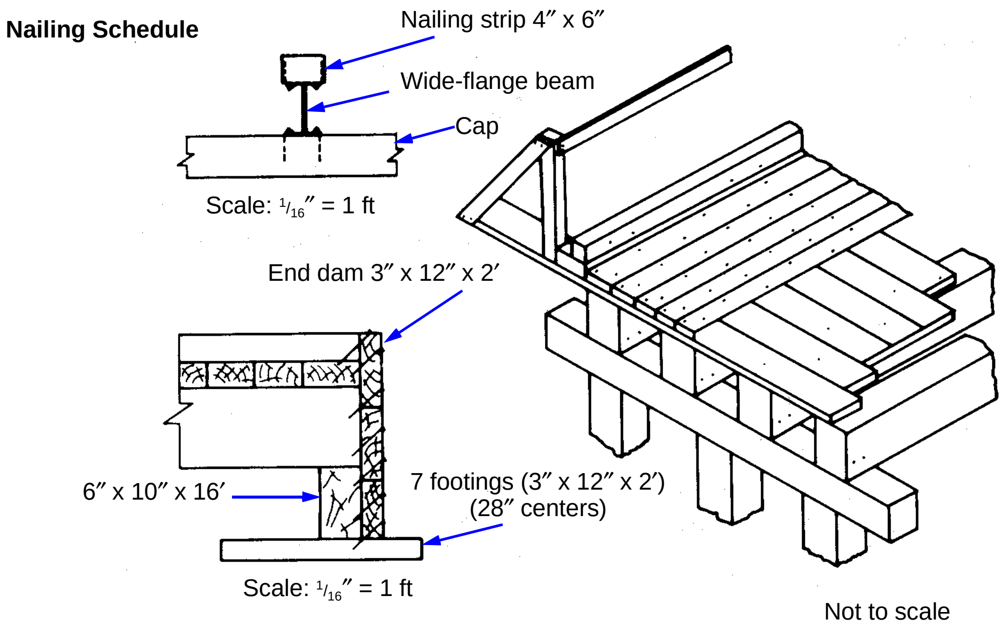


Figure 10-5. Assembled-View Drawing

Specifications

10-10. Separate written specifications may accompany the working drawings. The specifications list the quality and size of materials required. The list does not identify how the quality is determined, only the quality required *(Figure 10-6, page 10-6).*

BILL OF MATERIALS

10-11. The AFCS (discussed in *Chapter 1*) provides the bill of materials for all standard designs. Nonstandard designs require takeoffs from the drawings to develop the bill of materials. The AFCS lists each main member by piece number, piece description, line number, drawing reference, quantity, mark, size, required length, unit weight, and total weight.

LABOR REQUIREMENTS

10-12. The AFCS also lists labor requirements for constructing standard designs, which is an effective template for determining labor requirements of nonstandard designs. Labor requirements are determined only after the working drawings are complete. Sources of labor for bridge construction are combat troops, civilians, and prisoners of war. Civilian labor is preferred to combat troops or prisoners of war. Using prisoners of war as a labor source requires special considerations as outlined in *FM 19-40*.

Type	Material Size	Use
20d nail		General handrail and bracing
60d nail	6″	Tread to deck
60d nail		Nailing strip to WF beam
60d nail		Toenail stringers
60d nail		End dam
60d nail		Toenail curb and curb riser
8″ spike	8″	Deck to stringer
Weld	C 6 x 13 to W12x45	Diaphragms to steel stringers
5/8 ϕ x 24″ driftpins		Stringers to cap
1/2 ϕ x 16″ driftpins		Curb and curb riser to stringer
1/2 ϕ x 16″ driftpins		Cap and sill to posts

Class-50 Single-Lane
Nonstandard
Highway Bridge
Timber-Bent Support

Drawn Approved

Figure 10-6. Sample Specification List

EQUIPMENT REQUIREMENTS AND AVAILABILITY

10-13. A construction plan should identify all the equipment that is necessary for construction. A responsible engineer must ensure that all required equipment and associated, skilled operators are available. If the required equipment is not available, the engineer must determine the appropriate expedient capacity or adjust the design to accommodate the available construction equipment.

SCHEDULING

10-14. Scheduling involves preparing manpower and construction timelines. These schedules coordinate construction effort and resource allocation. Accurate schedules are detailed timeline plans for constructing a bridge. The schedules' accuracy depends on the estimates made during the planning process. These schedules take many forms (tabular, bar graph, coordinate graph, labor block, and so forth). Scheduling is discussed in detail in *FM 5-412*. Two important schedules are manpower and construction.

Manpower

10-15. A manpower schedule lists the total work-hour requirements for each activity that are necessary to complete the bridge. *Table 10-1* contains partial data concerning work hours normally required to perform specific operations. This information would be needed to develop a manpower schedule. Task analysis provides the basis for determining the required manpower to complete the project.

Table 10-1. Required Work Hours for Specific Operations

Operation	Unit	Work Hours per Unit	Personnel in Crew
Steel			
Bolting	Bolt	0.060	2
Drilling	Linear feet	3.200	2
Span erecting	Ton	2.500	9
Pattern making	N/A	N/A	2
Timber			
Bolting	Bolt	0.133	2
Boring	Linear feet	0.100	2
Driving nails	Nail	0.003	1
Other			
Excavating (hand)	Cubic yard	1.000	7
Handling piles	Pile	1.000	7

Construction

10-16. A construction schedule serves as an operational guide for supervisory personnel. It is a means of efficiently coordinating all construction efforts. *FM 5-412* provides detailed guidance for setting up a schedule.

10-17. Construction schedules are useful during all phases of construction.

- **Before construction.** This schedule shows the sequence in which personnel, material, and equipment are required. Information on the schedule allows the construction force to integrate their activities to accomplish maximum efficiency.
- **During construction.** This schedule serves as a logical basis for issuing instructions and maintaining control. Information on the schedule also allows construction supervisors to distribute and ensure that equipment and labor are at the right place at the right time. The information also allows the engineer to analyze the overall status of the bridge and to use this information as a basis for reporting to higher headquarters (HQ).
- **After construction.** Evaluating the schedule allows engineers to recognize errors in estimating, scheduling, and resource use. The evaluation process provides engineers with information for improving the planning process.

SURVEY REQUIREMENTS

10-18. Precision surveying in bridge construction prevents time-consuming mistakes. See *FM 5-233* for detailed surveying procedures. Accurately locate all components before beginning construction. Check the component locations continuously during construction. Place reference stakes from which centers can be reestablished outside of the immediate construction area, if possible. Otherwise, use guard stakes and flags to mark reference-stake locations. If any location stakes or lines are disturbed during construction, accurately relocate them. Establish pile cutoffs using instrument procedures, not by reckoning or rough measurements.

Equipment

10-19. Good equipment is essential for both timber and steel bridges. The equipment used in construction surveying is a transit, a level, a steel tape, stakes, and steel tacks. Compare the tapes used for surveying with the tapes used for fabricating and framing parts to ensure that discrepancies do not exist between the tapes. After driving location stakes, add steel tacks to the stakes to mark exact reference points.

Horizontal and Vertical Control

10-20. Establish benchmarks near each end of the bridge and at other convenient locations near the construction area. Use a transit and tape and, when necessary, triangulation to control horizontal measurements. Use differential leveling to control vertical measurements and to locate accurately all bearing supports. Use the bridge centerline as a reference point for all centering measurements.

Centerlines

10-21. The construction plan establishes the bridge centerline. The bridge centerline usually coincides with the site-survey centerline. Mark the centerline with stakes set at each end of the bridge.

Foundation Placement

10-22. A starting point at one abutment (fixed by the construction plan) establishes the centerline locations of the other abutment and of each foundation. After finishing the foundations, accurately mark the centers of the bearing supports on the foundations.

Anchor Bolts

10-23. Use particular care in locating anchor bolts. Check the bolt locations after completing the forms and immediately before placing the concrete. A wood template is helpful when positioning anchor bolts.

Working Platforms

10-24. Where performing direct measurements on the ground is impossible, build temporary platforms at the centers of each bent. Use these platforms for measuring and working.

Piles (In Water)

10-25. Pile placement in riverbeds or streambeds presents a measurement problem. See *FM 5-134* for techniques on accurately placing piles in riverbeds or streambeds.

Grillages

10-26. Construct steel grillages in the fabrication yard. Because of their weight, grillages require a crane for placement. Set grillages in concrete bedding to obtain a full, uniform bearing capacity.

MATERIAL PREPARATION, TIMBER FRAMING

10-27. Framing is the process of cutting, shaping, and boring timber. Consider the information below when preparing timber.

WOOD PROPERTIES

10-28. Unlike other structural materials, wood does not have the same physical properties in all directions. In compression, tension, and bending, a wood's strongest dimension is in the direction of the grain. In shear, a wood's strongest dimension is across the grain. Wood splits easily along the grain but not across it. Wood shrinks more across the grain than with the grain. Timbers used together should be of the same type and equally seasoned.

WORKMANSHIP

10-29. Construction workers should be experienced with woodworking tools. Framing, cuts, and dimensions must be accurate to ensure proper fit and adequate capacity. Carpentry tools and framing methods are discussed in *FM 5-426*.

LAYOUT

10-30. Use the platform or the nonplatform method to lay out bents and towers:

- **Platform method.** Draw the outline of the bent or tower to be constructed onto the platform. Lay timbers on the outline and mark them for cutting. Mark the timber as to its location in the structure before removing the timber from the platform. *Figure 10-7, page 10-10,* shows the procedure for aligning the timber piles to be used for bents and towers.
- **Nonplatform method.** Carefully measure and mark each post for cutting. To eliminate variations in measurement, use a 1- by 2-inch measuring stick, premarked with the controlling dimensions. Use the measuring stick in place of a tape or rule.

MATERIAL PREPARATION, STEEL FABRICATION

10-31. Lay out a fabrication yard to suit the fabrication procedure and the size of the bridge *(Figure 2-1, page 2-4)*. The yard must be on firm, level ground and should provide ample space and easy access to the bridge site. Divide the yard into the following areas:

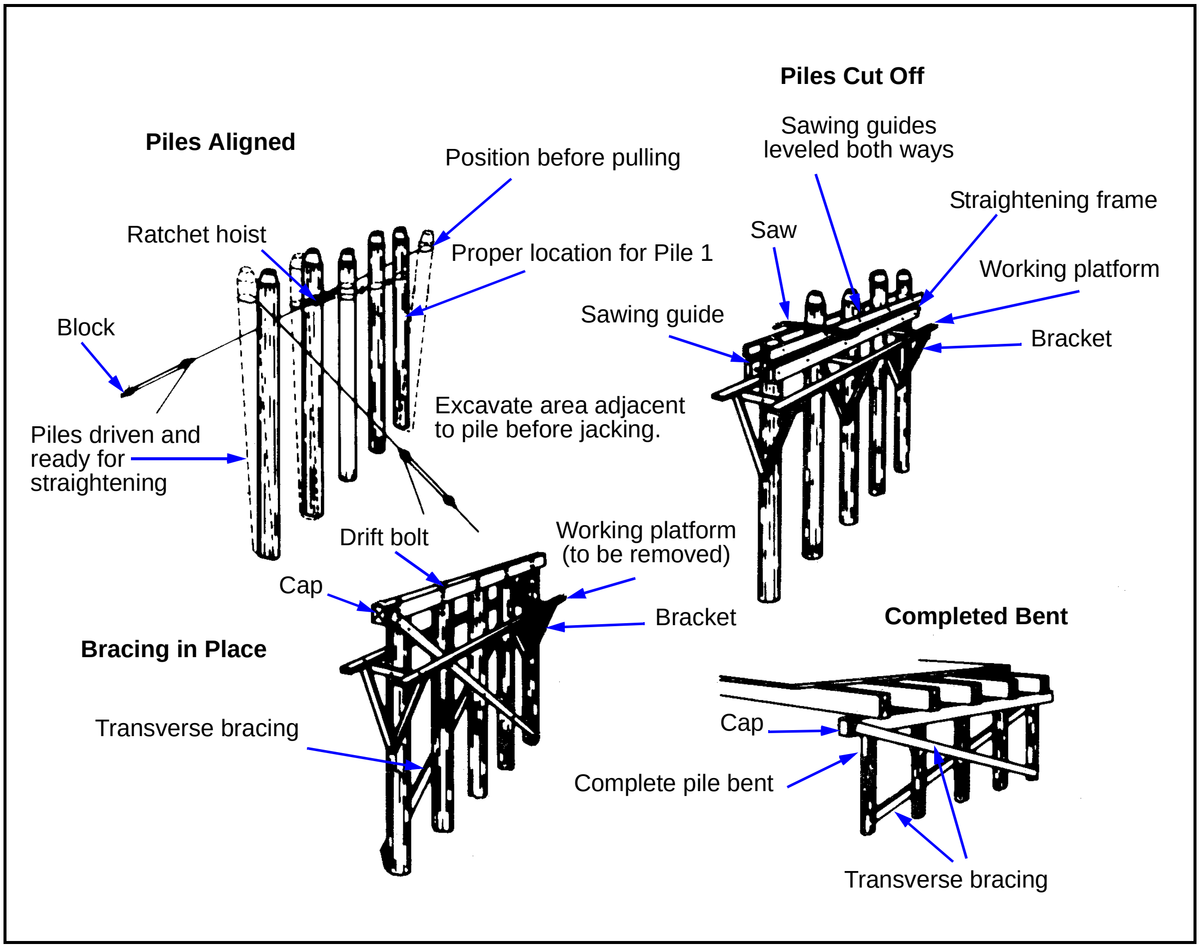


Figure 10-7. Procedure for Aligning Timber Piles into Bents

- **Raw-material storage.** Provide an area for stock-length steel. As material arrives, check its condition and store it with other materials of the same size. Storage should allow easy access, and those materials that will be needed first should be near the front of the storage area.
- **Layout area.** Provide an area for laying, cutting, and drilling parts.
- **Assembly area.** Provide an area for processing (drilling, reaming, bolting, riveting, welding, and so forth). This area should also have waist-high blocking to permit work on the underside of the assembly.
- **Component storage.** Provide an area to store fabricated assemblies.

TOOLS AND EQUIPMENT

10-32. Tool and equipment selection depends on the fabrication method. Use only steel squares, rulers, and tapes for measurement. A crane should be available for loading, unloading, turning assemblies in process, and moving finished assemblies. Personal protective equipment (goggles, safety belts, and so forth) should also be available.

WORK SCHEDULE

10-33. Start fabricating steel components early enough to allow their availability when needed during the erection process. Organize work on an assembly-line basis, and assign a crew responsibility for each class of members or components.

SAFETY

10-34. Commanders are responsible for safety. Safety controls should outline proper conduct of personnel during construction activities.

PERSONNEL

10-35. Personnel should—

- Stand clear of suspended loads.
- Stand away from and out of the line of the ropes that are under heavy strain.
- Check the equipment and rigging before swinging heavy loads.
- Move heavy loads slowly.
- Keep heavy loads under control at all times.
- Consider the load's inertia when determining how adequate a rig is.
- Guide the loads to prevent them from swinging.
- Never lift the loads in heavy winds.
- Never swing the loads over working personnel.
- Never ride the loads being lifted or placed.
- Stand clear of moving loads and their path of movement.
- Never stand under a block and tackle.
- Never locate matching holes with fingers or hands.
- Never stand or work under areas where falling tools or parts are a hazard.
- Use all the required personal protective devices and other safety equipment.
- Never sit or stand on deck rails, shafts, winch heads, or other places where danger of falling exists.
- Never operate or ride equipment unless authorized.
- Take time to construct adequate working platforms properly.
- Lift heavy objects with their legs, not their back.
- Never leave intermediate construction unattended without adequate temporary bracing.
- Never walk near the edge of a deck until it has been securely fastened to the stringers.

SCAFFOLDS

10-36. Personnel should observe the following guidelines:

- Scaffolds should be strong enough to support the intended loads and secure against sliding and overturning.

- Scaffolds over 6 feet high should have a guardrail on the back side.
- Loose boards should not extend beyond their supports.
- Nails used in scaffolds should be driven fully and not used in tension.
- Scaffold horses should be supported evenly and nailed to the platform on which they are used.
- Ladders should be blocked at the foot or tied at the top to prevent sliding.

TACKLE

10-37. Personnel should—

- Inspect the tackle frequently.
- Check the wire rope for fraying. Remove the wire rope when 4 percent or more of the total number of wires in the rope are broken.
- Use wire rope slings instead of chain slings whenever possible.
- Place wood blocks between slings and steel loads to prevent slings from being cut by the load.
- Use shackles instead of hooks for attaching blocks (mouse the blocks if using hooks).
- Always use blocking or cribbing to secure the necessary height under the jacks. Never set the jacks on a post or strut where the jacks might kick sideways under strain.
- Never permit loose lines to hang from the structure or from equipment.

HEAVY EQUIPMENT

10-38. Personnel should—

- Always inspect all equipment thoroughly for proper operation before use.
- Never operate defective equipment.
- Never mount or dismount equipment when it is moving or in operation.
- Never ride (as a passenger) equipment not intended to transport passengers.

ERECTION-EQUIPMENT CAPACITY

10-39. Examine each principal member and subassembly to determine if it is possible to erect it safely with available equipment. If not, modify the erection procedure or obtain the necessary equipment to do the work. Test each piece of equipment at the site before attempting to lift subassemblies, especially if the subassemblies will stress the equipment near its maximum capacity.

SPECIAL EQUIPMENT

10-40. *Table 10-2* shows a list of special equipment that is required for erecting a bridge. These tools are needed in addition to the small hand tools normally organic to a construction unit.

Table 10-2. Special Equipment

Description	Number Required
Crane shovel (track-mounted, 20-ton, 3/4-cubic-yard)	1
Crane shovel (crawler-mounted, 12 1/2-ton, 3/4-cubic-yard)	2
Lead (pile-driving, steel-hanging)	1
Hammer	1
Jetting set (portable)	1
Compressor (air, trailer-mounted, 600-cubic-foot-per-minute)	2
Mixer (concrete, gas-driven, trailer-mounted, 16-cubic-foot)	1
Wheelbarrow (3-cubic-foot) (with a steel tray and handles)	12
Pump (55-gallon-per-minute [GPM], centrifugal, gas-driven, base-mounted, 2-inch discharge)	1
Drill (steel, pneumatic, portable, nonreversible)	8
Tool kit (rigging, wire-rope)	1
Tool kit (blacksmith, general)	1
Tool kit (pipe-fitting)	1
Survey set (general-purpose)	1

HAND TOOLS

10-41. A construction unit also requires hand tools. Some special tools are required for erecting steel bridges. Examples are sledgehammers, crescent and ratchet wrenches, driftpins, long-handled structural-offset wrenches, and 2-foot connecting bars.

RIGGING

10-42. Refer to *FM 5-125* for additional information on rigging. Rigging tools and their uses are discussed in detail.

TRUCK- AND CRAWLER-MOUNTED CRANES

10-43. Truck- and crawler-mounted cranes are preferred for erecting bridges. They can enhance the construction process by moving out over successively completed spans. If conditions permit, operate these cranes from the ground. When working over water, place these cranes on rafts or barges. Truck-mounted cranes are suitable for erecting structures of moderate span. On larger bridges, use cranes to supplement the main erection units. Truck-mounted cranes are highly mobile but require a firm, level operating surface.

10-44. Crawler-mounted cranes are better suited for general erection use, but they are less mobile than truck-mounted cranes. Crawler-mounted cranes are capable of operating over rough ground and ground that is too soft for truck-mounted cranes. Crawler-mounted cranes can be used in water that is no deeper than the top of the crawlers (if the bottom is firm).

DERRICKS

10-45. Generally, guy or stiff-leg derricks will be used. Neither is economical unless continued operations are within reach of their booms. Guy derricks consist of a mast, a boom pivoted from the foot of the mast, guys, and tackle. If the guy lines to the top of the mast are clear of the end of the boom, the boom may swing completely around the mast. Loads are lifted and moved by manpower or by an engine-driven hoist.

10-46. Stiff-leg derricks consist of a mast held vertically by two inclined struts connected to the top of the mast. The struts are spread between 60 and 90 degrees and are attached to sills extended from the bottom of the mast to provide stability. The mast and boom of the stiff-leg derrick is capable of swinging in a 270-degree arc. Refer to *FM 5-125* for more information on derrick fabrication.

CABLEWAYS

10-47. The medium cableway developed for military operations is capable of effectively erecting timber and steel towers and launching light stringers. The maximum span is 1,200 feet. The tower height is 63 feet. The rated capacity is 3,000 pounds, but a load of 4,000 pounds is possible if using caution during lifting operations. Installation requires about 6 hours (by an experienced unit). The total weight of the cableway is 20,000 pounds, which permits it to be transported on four trucks. Install the cableway with the base of the cableway towers about at grade and on the centerline of the bridge being constructed. Refer to *FM 5-125* for more information on cableway installation.

HOISTS

10-48. Drum hoists consist of one or more winding drums, a train of reducing gears, and a power source. They may carry one or more winches or capstan heads for handling secondary lines. These hoists are attached to construction equipment such as derricks or cranes. A winch configured for attachment to a boom or mast is called a *crab hoist*. Winches are used with gin poles, shears, and derricks. Chain hoists are used for raising and holding loads and are particularly useful when accurate load placement or adjustment is necessary.

JACKS

10-49. Jacks are used to raise or lower heavy loads short distances. They are available in capacities from 5 to 100 tons. Small-capacity jacks usually employ a rack bar or screw as the lifting mechanism. Large-capacity jacks are normally operated hydraulically. The following common jack types are used in bridge construction:

- **Pushing and pulling.** These are screw jacks of 10-ton capacity. They have end fittings, which permit the pulling together or the pushing apart of components. Their principal function is to spread or brace parts or to tighten lines or lashings.
- **Ratchet leveling.** These are rack-bar jacks equipped with foot lifts. The foot lifts allow low-clearance loads that are close to the base of the jack to be lifted.
- **Hydraulic.** These jacks operate on the piston-cylinder principle. Oil pumped through a line into a liquid-tight cylinder forces the piston to move against the load. Ordinarily, a slow oil leak prevents the jacks from holding the load in an exact position over long periods.

FALSEWORK

10-50. Falsework denotes any construction intended to assist erection operations only. Falsework includes temporary towers, bents or trestles, fixed and floating platforms, staging, runways, ladders, and scaffolding, that are later removed or abandoned. Falsework is constructed from local materials whenever practical.

BENTS

10-51. Falsework bents are used to support long spans that are erected before splicing is completed or before a permanent tower or a bent supporting the outer end has been completed. Falsework bents must be well-built and securely braced.

TRESTLES

10-52. Falsework trestles allow erection equipment to operate over shallow water or soft ground. A trestle is built alongside a permanent bridge, allowing equipment to work on foundations, towers, and bents of long-span bridges. The trestles should be as light as possible and just wide enough to support the equipment that will use it.

PLATFORMS AND SCAFFOLDING

10-53. Drilling, bolting, and nailing are ordinarily done from scaffolds. These scaffolds are carried up from story to story as erection advances. Operations such as fitting-up, riveting, and welding require hanging scaffolds called floating platforms. Two workers can easily move these platforms from connection to connection. Two of these platforms are usually needed at each connection.

ERECTION-EQUIPMENT TECHNIQUES

10-54. A step-by-step erection procedure and the necessary, or preferred, equipment are determined in the planning stage. Bridge size, site conditions, skill of construction personnel, and available equipment determine which construction technique to use. Detailed erection plans should include equipment requirements, locations, and capabilities and the tabulated weights of all the bridge members to be erected. Various equipment configurations and their employment are detailed in the paragraphs below.

GROUND-BASED CRANES

10-55. Where site conditions permit, erect long-span bridges of moderate height from ground level or from rafts. A medium-size, crawler-mounted crane is more maneuverable than a truck-mounted crane. A crawler-mounted crane is also capable of operating over rougher and softer ground. Follow the sequence below for this method of construction:

Step 1. Raise the tower supports (if any).

Step 2. Raise the outside stringers. Use two cranes or a combination of a crane and gin poles to raise and place both ends of the stringer simultaneously.

Step 3. Raise the interior stringers using the same technique as used for the outside stingers.

Step 4. Install the diaphragms and the bracing.

Step 5. Complete all connections.

Step 6. Install the deck.

Step 7. Move to the next span and repeat the process.

DECK-BASED CRANES (WITHOUT FALSEWORK)

10-56. This method is best when the economy of material, labor, and time are important and the bridge consists of relatively short spans. A medium-size, truck-mounted crane is appropriate for this work. The technique used will depend on the substructure.

Pile Bents and Piers

10-57. After delivery of any prefabricated parts to the construction site, proceed as follows:

Step 1. Construct the first pile bent or pier with the crane at the abutment.

Step 2. Set the stringers for the first span between the abutment and pile bent or pier.

Step 3. Lay a temporary deck capable of supporting the crane.

Step 4. Move the crane onto the temporary deck. Park the crane at the first pile bent or pier. Repeat the above steps for each subsequent span.

Framed Timber Towers

10-58. After the foundations have been completed, proceed as follows:

Step 1. Set the foundation sills and anchor to the piles with scabs or drift bolts or to the foundations with anchor bolts.

Step 2. Place the preassembled tower bent on the sill. Construct multistory towers one story at a time.

Step 3. Brace the sill and tighten the anchor bolts or other connections.

Step 4. Complete the tower using the steps above.

Step 5. Set the stringers and install the deck.

Step 6. Install the longitudinal tower bracing.

Step 7. Move the crane onto the deck and remove the temporary bracing. Repeat the above steps for each subsequent span.

DECK-BASED CRANES (WITH FALSEWORK)

10-59. Falsework is advantageous when building moderately high bridges over water or bridges over ground that is too soft to support the erection equipment. This method of construction is not justified for bridges over 40 feet high. Falsework bents may be pile bents or well-braced timber bents. Allow for 1 to 2 feet of blocking between caps and the bottoms of stringers when this falsework is in position. Follow these steps when constructing a 90-foot span using falsework:

Step 1. Construct a falsework bent about 20 feet from the abutment.

Step 2. Set the first sections of the completed stringer between the abutment and the first falsework bent. Block the stringer sections to prevent them from overturning.

Step 3. Install temporary decking and move the crane onto the deck.

Step 4. Construct the second falsework bent about 20 feet from the first falsework bent.

Step 5. Set the second sections of the completed stringer between the falsework bents, splicing the stringer sections with temporary splices. Do not install the final connections at this time.

Step 6. Install temporary decking and move the crane onto the new deck.

Step 7. Continue this process until the full 90-foot span rests on the permanent intermediate support and the abutment.

Step 8. Align all the stringer sections and complete the permanent connections.

Step 9. Install the diaphragms and bracing.

Step 10. Remove the falsework.

STEEL GIN POLES

10-60. Gin poles are necessary for erecting high steel towers. Each tower column requires a separate gin pole. Use single-drum pneumatic hoists for hoisting lines, when possible. Use hand winches for holdback lines. Gin poles (along with shears) can also be used to place stringers *(Figures 10-8* and *10-9, pages 10-18* and *10-19)*. The following procedure shows how to erect a multistory tower:

Step 1. Set the gin poles on the blocking that is adjacent to the column foundations.

Step 2. Set the columns on their foundations and install and tighten the anchor bolts.

Step 3. Install the transverse bracing of the first story, bottom strut, diagonals, and top strut. The top strut is the bottom strut of the next story. Use drift pins or other temporary devices for all bracing connections until the whole tower is plumbed and squared.

Step 4. Install longitudinal bracing on the first story using the same process as transverse bracing.

Step 5. Raise the gin poles (using tackle) to the top of the first story in preparation for erecting the next story. Support the gin poles laterally by using the brackets that are installed on the columns. Use temporary straps to guide the gin poles as they are raised.

Step 6. Set the columns for the next story and temporarily splice them to the last story's columns. Erect the column caps by using temporary connections. Lean the gin poles away from the columns during cap erection.

Step 7. Install the transverse diagonal bracing.

Step 8. Install the longitudinal bracing.

Step 9. Repeat the above process for each subsequent story of the tower.

Step 10. Install the stringers.

Step 11. Plumb and square the tower.

Step 12. Install the permanent connections in the tower components.

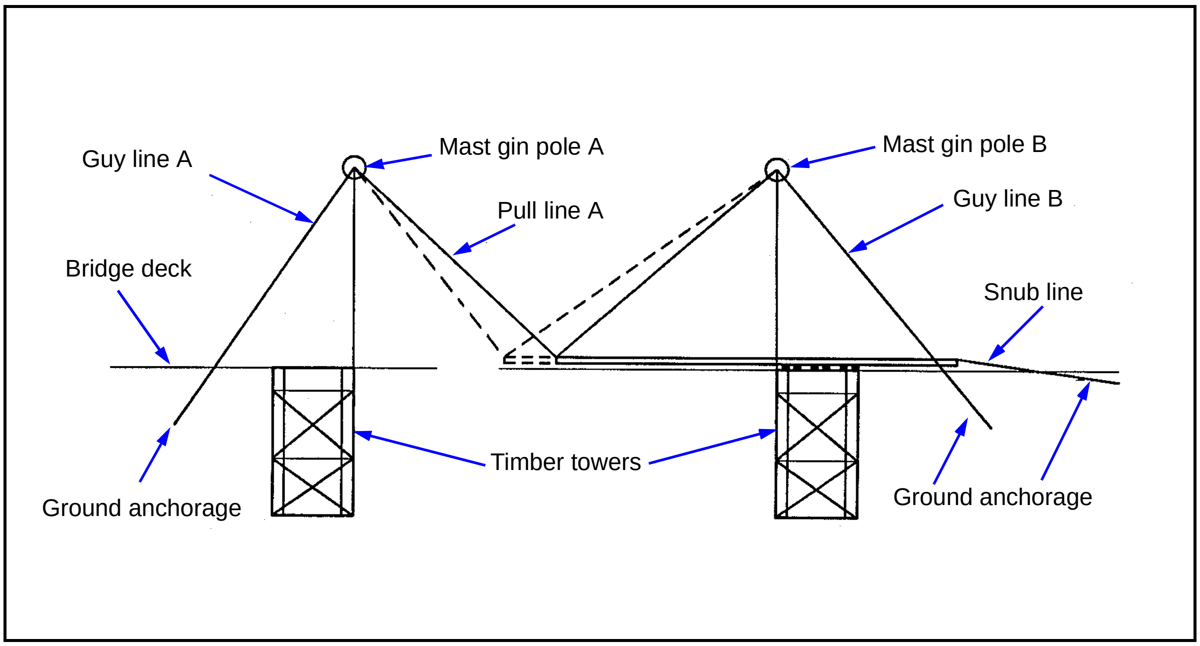


Figure 10-8. Launching Stringers by Gin Poles

DERRICKS

10-61. A derrick is the timber counterpart of a gin pole and is used to erect tall timber towers. Only one derrick is needed per tower. A derrick is fabricated from timber that is equal in size to the tower materials and the Class IV or organic equipment. Hand winches provide control through hoist and boom lines. Derricks are anchored on the cap or sill. Erect a multistory tower as follows:

Step 1. Set and anchor the sill to the foundation.

Step 2. Assemble the derrick as shown in *Figure 10-10, page 10-20*. Anchor the mast guy lines to the extreme corners of the tower.

Step 3. Set the first of the prefabricated tower bents (end bents) on its sill. Each prefabricated bent consists of the posts, cap, and transverse bracing for

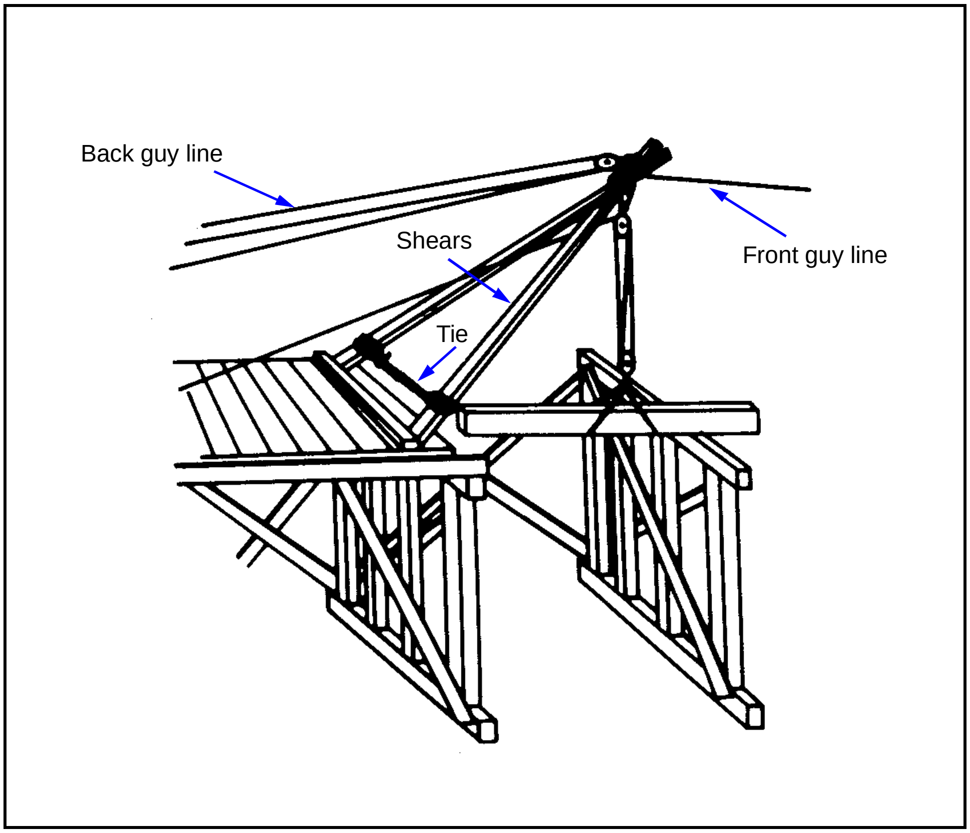


Figure 10-9. Launching Stringers by Shears

each story. Spread the bracing slightly so that it does not obstruct installation over the sill. Reposition the guy lines before setting the next (interior) bent. Never remove more than one guy line at a time during an operation.

Step 4. Finish setting the remaining bents (end bent, then interior bent) in a similar manner, using temporary bracing to hold the sections upright.

Step 5. Install the longitudinal bracing on the first story.

Step 6. Move the derrick onto the cap of the first story. Repeat the above steps for each subsequent story.

DERRICK ELEVATION

10-62. Refer to *Figure 10-11, page 10-21,* and the following procedure to raise the guy derrick:

Step 1. Attach the tackle guys to the boom point. Raise the boom as closely to the mast as possible, and secure the guys to the boom point.

Step 2. Release the boom tackle from the point of the boom, and lash the tackle near its base *(Figure 10-11A).*

Step 3. Lower and seat the boom, using the mast as a gin pole *(Figure 10-11B).*

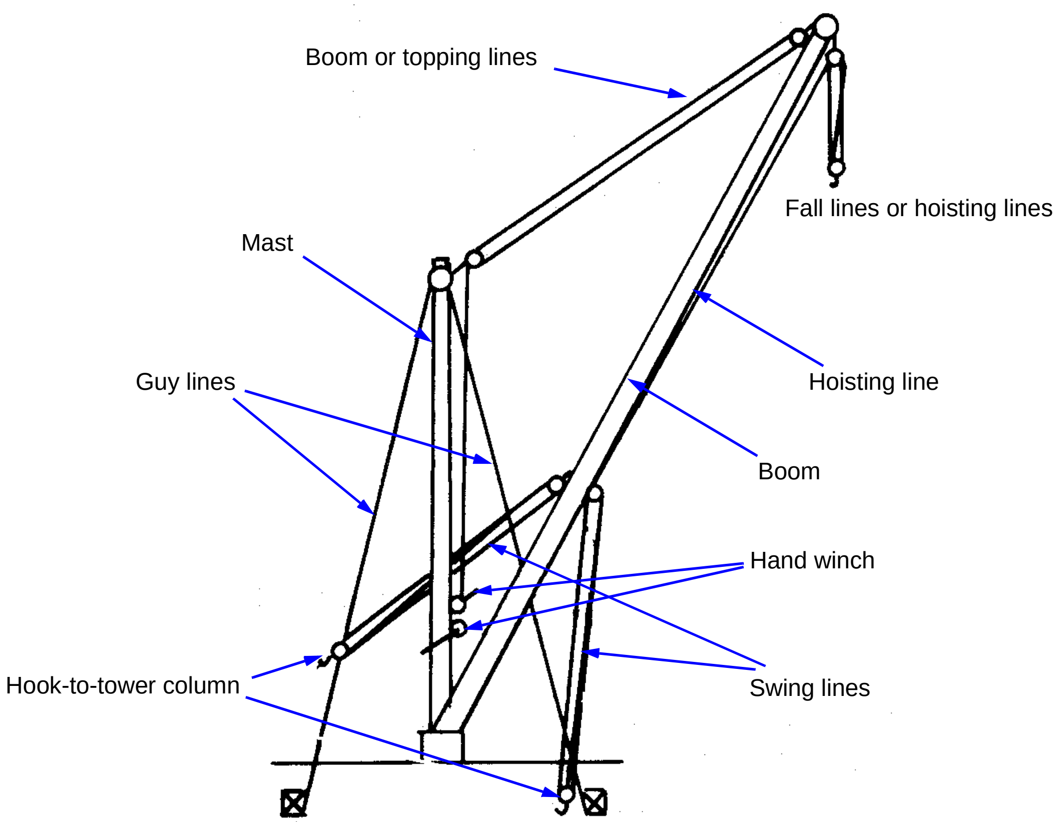


Figure 10-10. Guy Derrick in Working Position

Step 4. Release the boom tackle from the boom, and connect the hoisting tackle to the mast with lashing far enough down to lift the derrick at least 13 feet *(Figure 10-11C)*.

Step 5. Slacken the guy lines, and raise the mast and sill (using the boom as a gin pole) to the next higher level and seat it on the timber *(Figure 10-11D* and *E)*.

Step 6. Release the hoisting tackle from the mast, and lash the boom tackle to the boom near its base *(Figure 10-11F)*.

Step 7. Raise the boom, using the mast as a gin pole, and connect the boom at the next higher level. Use the guy lines to guide the boom as it is raised *(Figure 10-11G)*.

Step 8. Connect the tackle as shown in *Figure 10-10*, and release the guy lines to the boom point.

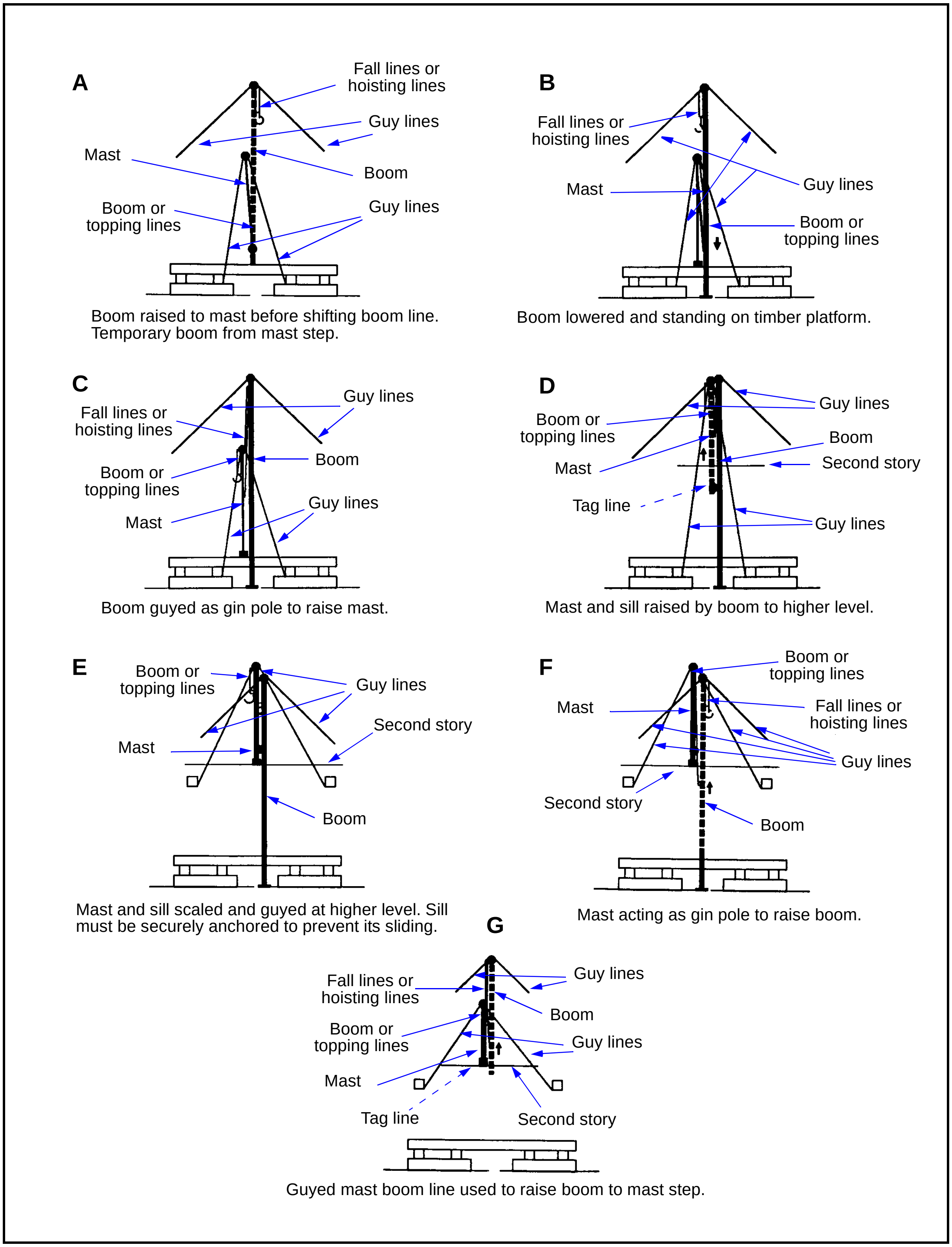


Figure 10-11. Raising the Guy Derrick

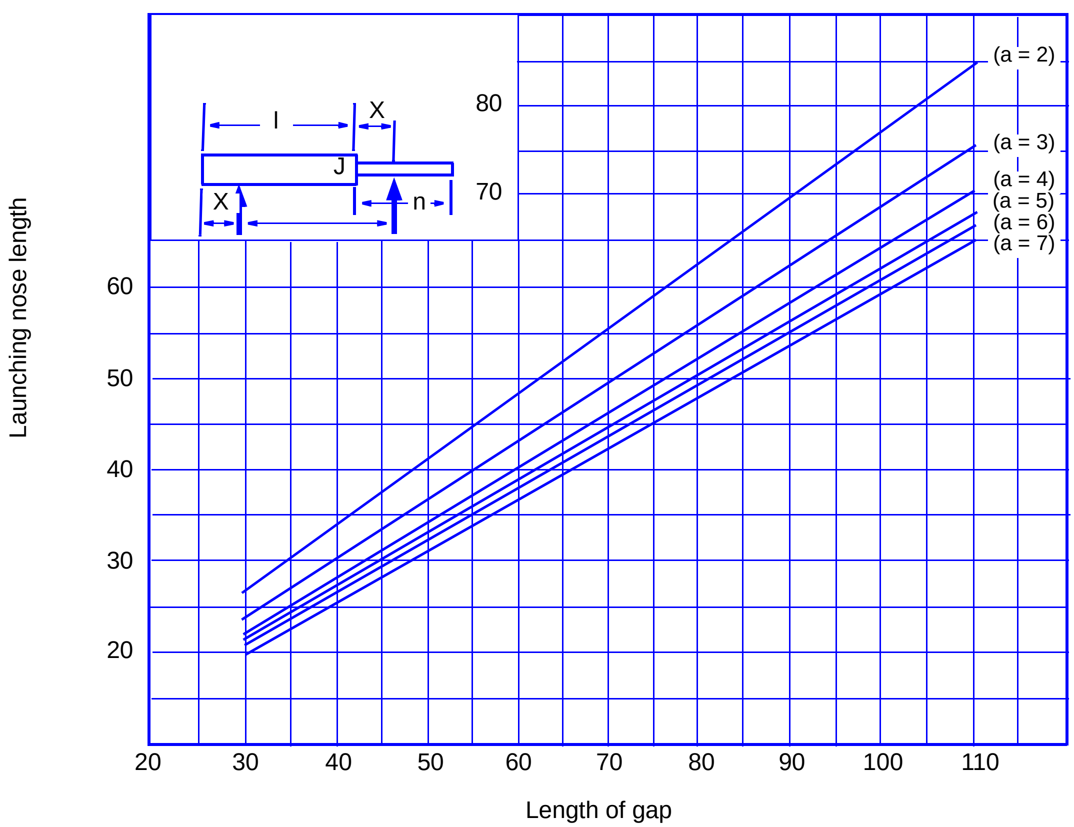
SPECIAL LAUNCHING METHODS (STEEL ERECTION)

CRANES

10-63. Whenever a suitable heavy crane is available and can be maneuvered effectively, use it to place the beams directly. The operator must be well trained to ensure safe operation.

LAUNCHING NOSE

10-64. This method uses a nose (extension to a beam) consisting of a lighter beam than the one being placed. This method is practical where there is only one span of two beams under construction. Use *Figure 10-12* to determine the required length of the launching nose. *Figure 10-13* shows this procedure.



LEGEND:
a = weight of beam:weight of nose ratio
l = bridge length
X = safety setback
J = bridge
n = nose

Figure 10-12. Required Length of the Launching Nose

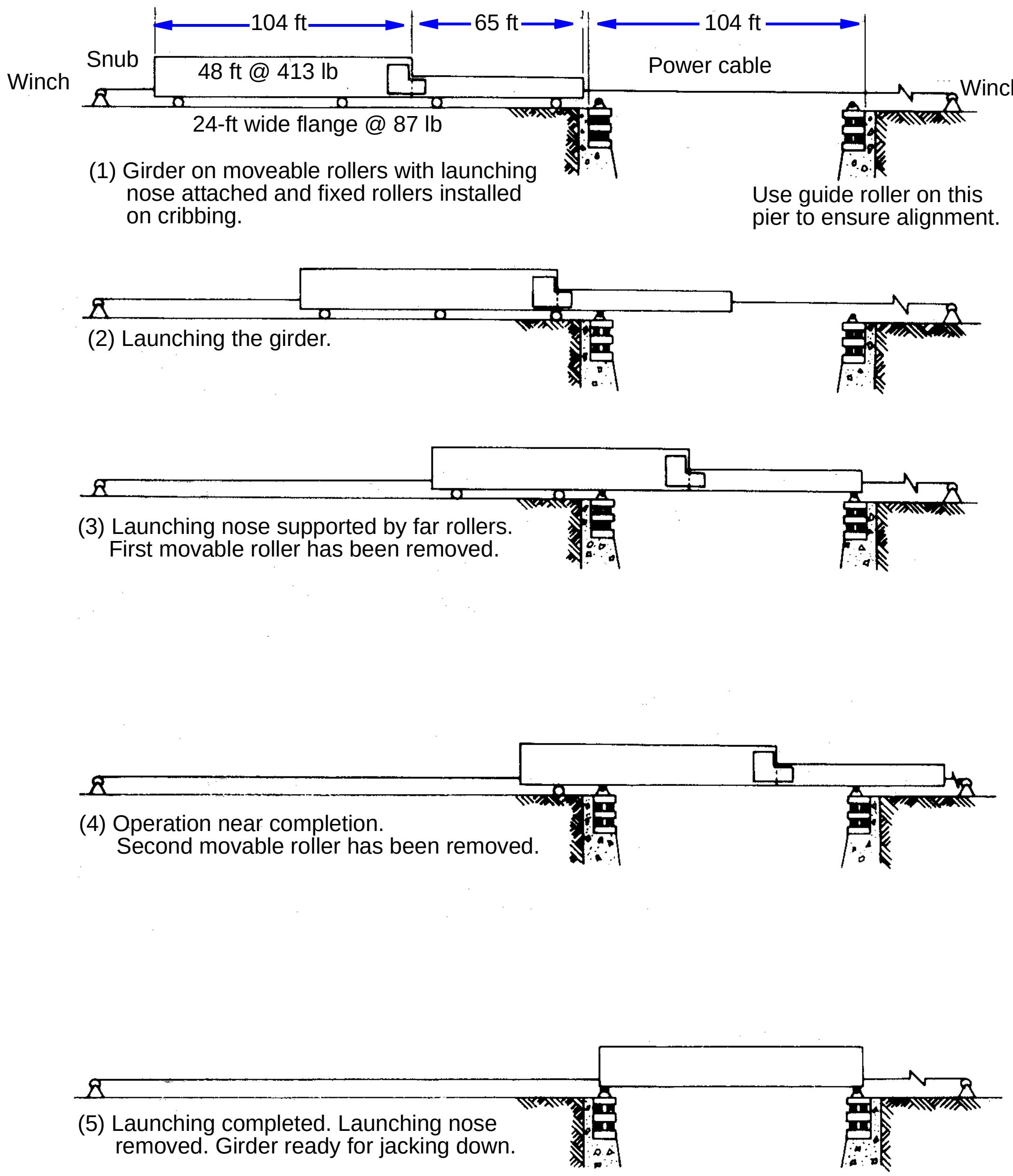


Figure 10-13. Launching Heavy Girders with a Light Launching Nose

COUNTERWEIGHT BEAM

10-65. Use this method if there is more than one span to a bridge, especially when the spans are of equal length or if there are four or more beams in each span. Site and material considerations may dictate a combination of the launching-nose method and the counterweight method. When constructing several spans, launch the spans one at a time *(Figures 10-14* and *10-15)*.

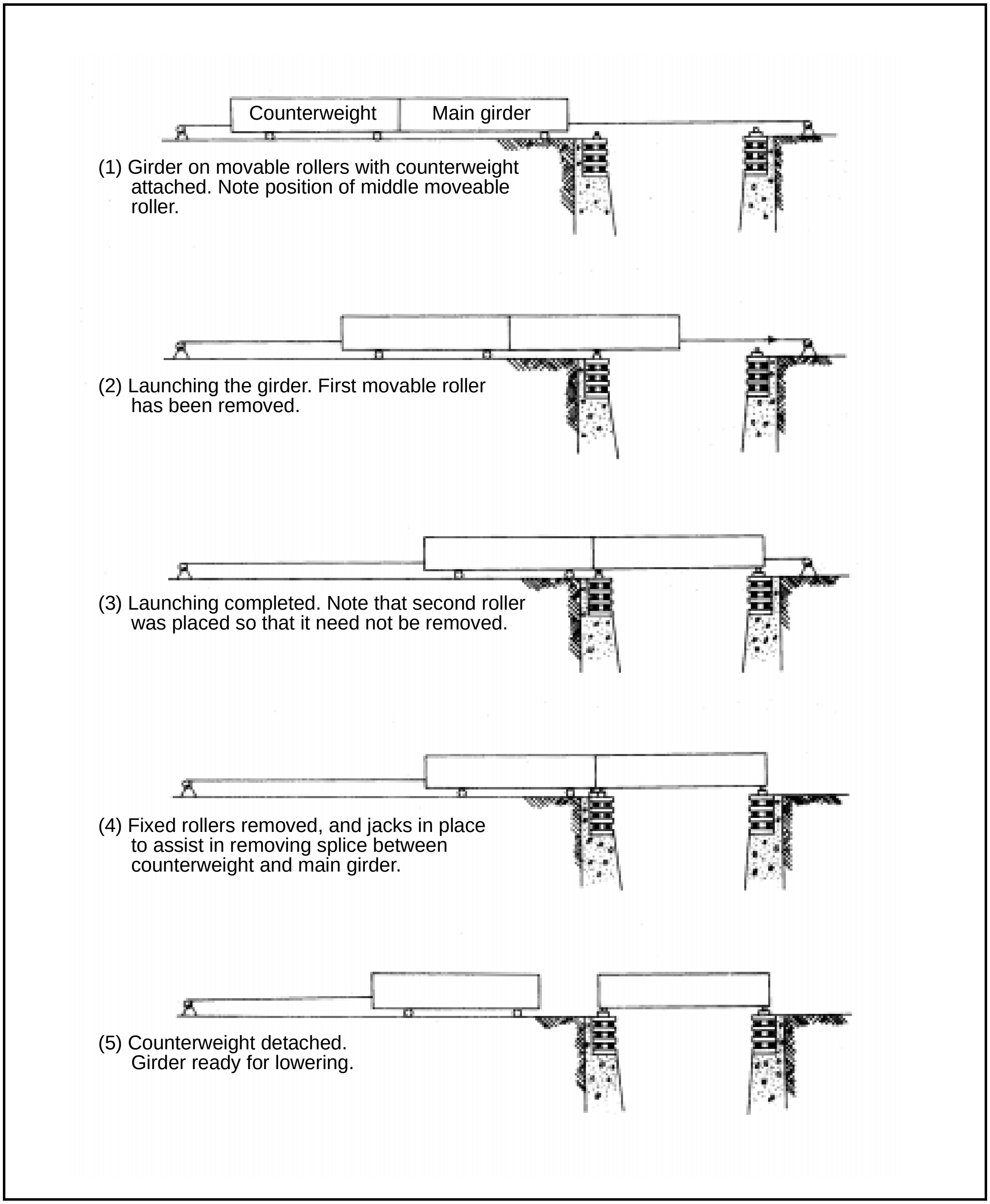


Figure 10-14. Launching Heavy Girders With an Equivalent-Weight Beam

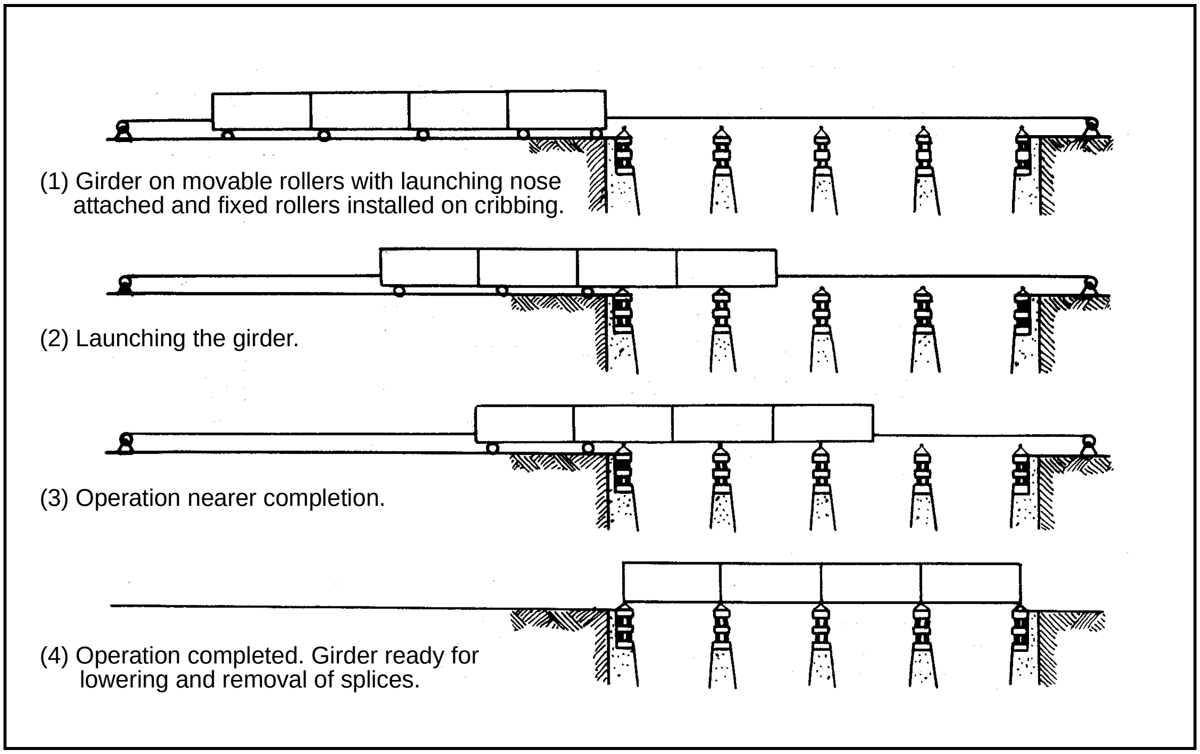


Figure 10-15. Launching Four Girders Simultaneously Over Four Equal Spans

LAUNCHING ROLLERS

10-66. Launching rollers may be used to erect a bridge. *Figure 10-16* shows a dolly made from two, 50-ton launching rollers.

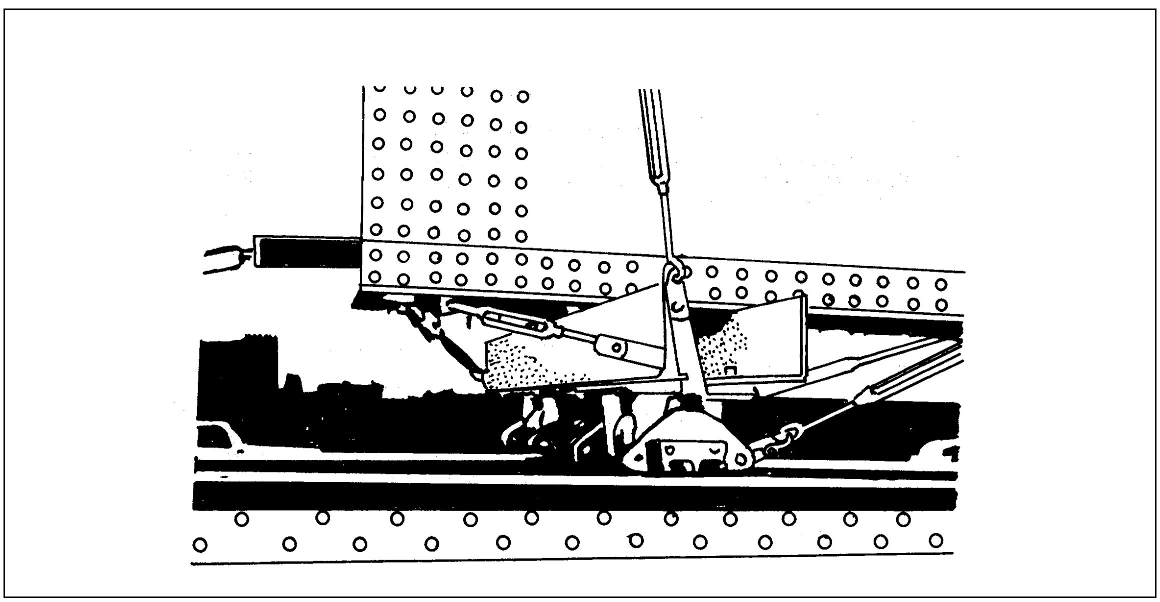
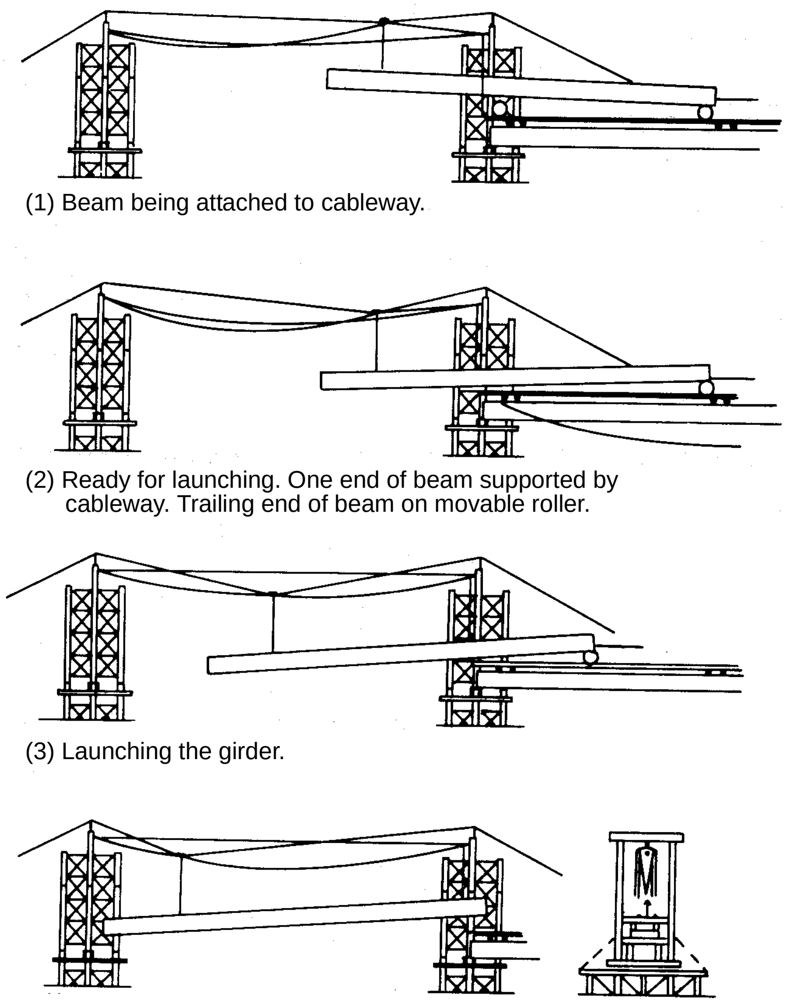


Figure 10-16. Dolly Made From Two, 50-Ton Launching Rollers

CABLEWAYS

10-67. Cableways *(Figure 10-17)* may be necessary if one or more of the methods described above will not work. End towers are usually constructed from standard steel trestles. The tension developed in the main cables should be considered. Evaluate the anchors carefully, since the cable tension developed by applying heavy loads can be very great. If the sag allowed is too great, it may be difficult to lift and seat a beam at the far pier. If the sag is small, the cable tension may be too high. Exact calculations for determining the amount of sag are not practical because of cable stretch from previous use and because cable stresses may be near the elastic limit of the steel.



(1) Beam being attached to cableway.

(2) Ready for launching. One end of beam supported by cableway. Trailing end of beam on movable roller.

(3) Launching the girder.

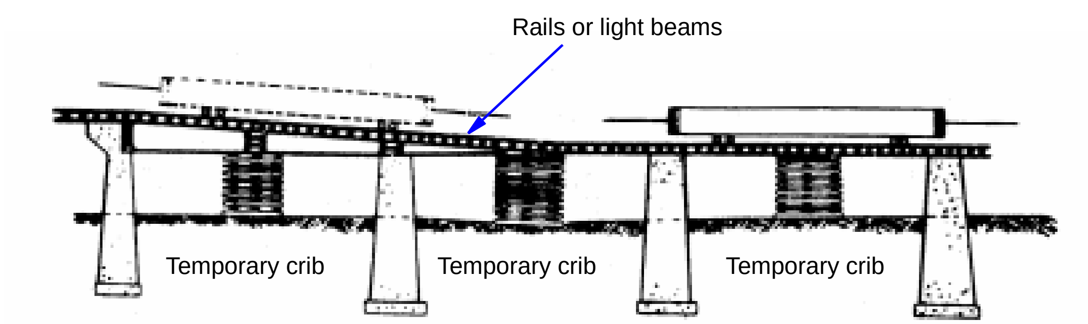
(4) Operation near completion.

Figure 10-17. Launching Heavy Beams by Cableway

10-68. Because cables elongate under a load, ensure that there is a way to loosen the cables after launching the beams. Doing so allows easier release of the beam from the hangers. Special take-up devices in the main cables may be needed.

CRIBBING METHOD AND RAILWAY-ENGINE OR ERECTION-CAR METHOD

10-69. *Figure 10-18* shows the cribbing method. *Figure 10-19, page 10-28,* shows the railway-engine or erection-car method.



After a beam has been rolled across a span, jack up. Remove rollers, runway, and cribbing. Lower the beam to the bearing plates.

Figure 10-18. Launching Beams by Cribbing

JACKING METHOD

10-70. If two beams are launched together or if one beam or girder is exceptionally heavy, the beam or group of beams can be lowered using a jack. *Figure 10-19* shows this method. With careful management, the beam can successfully be lowered from jack to jack without lowering it onto the cribbing and having to rejack the beam. Keep blocking under the beam at all times, and exercise extreme care when handling to prevent tilting and shifting of the beam. Use hydraulic jacks capable of lifting two to three times the expected load.

PRECAUTIONS

10-71. From observation and field experience, apply the following when erecting bridges using heavy equipment:

- Inspect all the erection tools for serviceability. Ensure that they are of the proper size and that sufficient quantities are on hand before starting construction.
- Inspect all the materials to ensure proper strength and fit. For example, ensure that the sheared ends of the web plates have no burrs

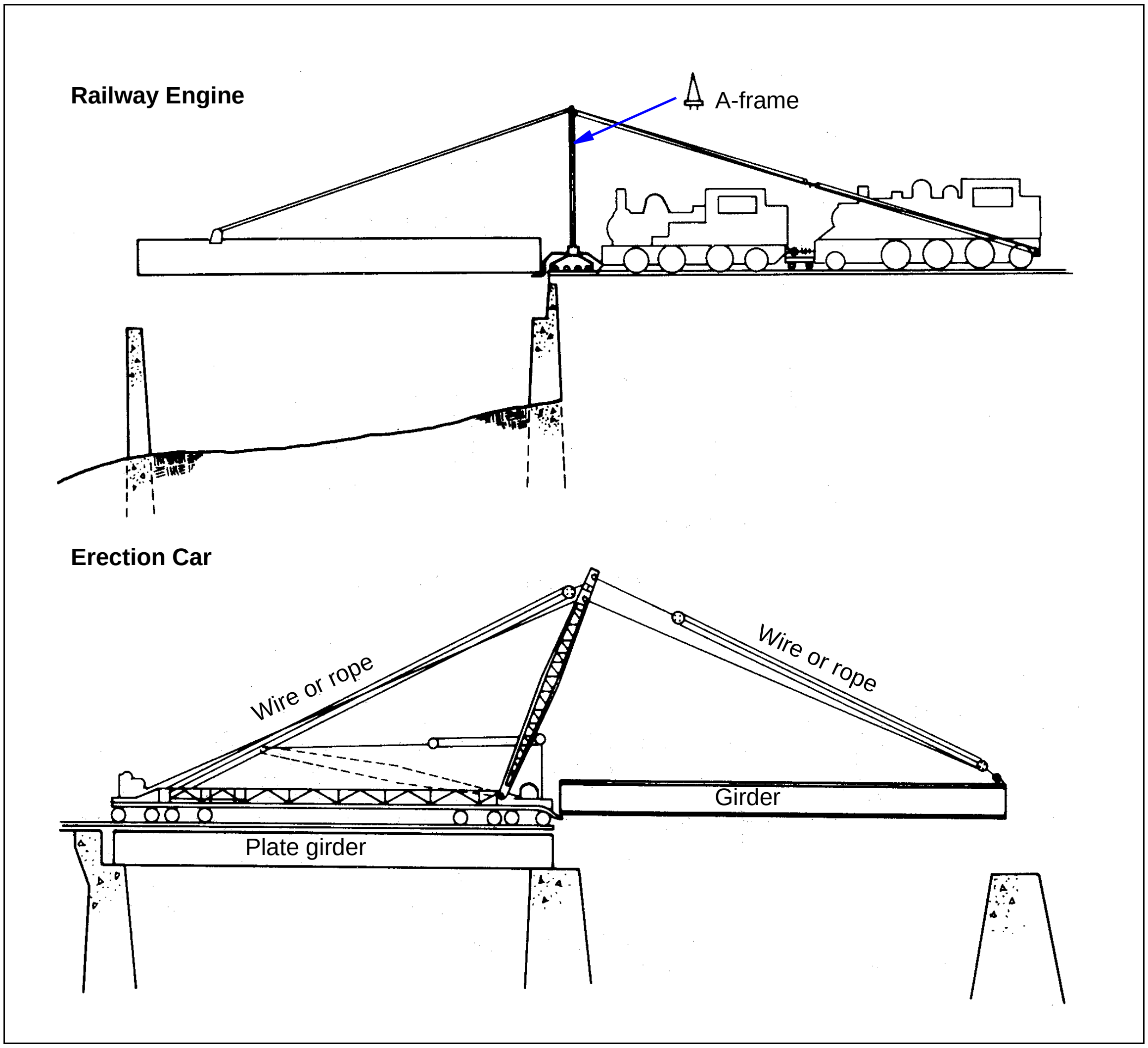


Figure 10-19. Launching Spans With Railway Engine and Erection Car

or obstructions to splicing or that splice-plate bolt holes are completely drilled and free of protective coating material.

- Consider launching long, continuous spans. This is more economical than other methods. Final positions of splices should be at places other than the center of individual spans, if practical.
- Give movable bearing ends careful attention. Parts of beams and bearing plates that are in contact should be smooth, clean, and well lubricated. Position the bearing plates carefully to ensure proper alignment for the temperature ranges expected.
- Exercise care to ensure that the beams are aligned properly and that driftpins pass completely through all parts during splicing operations. This reduces the possibility of having to ream the bolt holes. Insert the bolts through the bottom-flange splice plate with the bolt head down to avoid any interference with the launching rollers. Countersink the bolt and rivet heads into the top flange of the beam. Ensure that the

top and bottom of the beam are oriented properly when launched because countersinks are required on the top flange and not on the bottom flange.

- Install as many of the diaphragms and lateral braces as possible before launching the beams. Do not install diaphragms or lateral braces that may interfere with erection operations; wait until after the beam is launched. This will eliminate some of the work that must be conducted over open spans.
- Place preventer tacks and guy lines (in sufficient quantities to prevent mishaps) before launching.
- Ensure that the electrodes for overhead welding are the all-position type and of the correct polarity.

SUSPENSION-BRIDGE CONSTRUCTION

10-72. The site for a bridge must have sufficient area available for assembling the towers and hangers. Normally, stadia distances provide sufficient accuracy. If using 10-foot panels, the distance between the towers must be divisible by 20. Check the tower sites to ensure that the towers will be perpendicular to the centerline of the bridge. Mark and measure the distances to the deadmen.

ERECT CABLEWAY

10-73. To facilitate suspension-bridge construction, erect a cableway within 100 feet of the bridge site. The cableway will allow equipment and personnel to be moved over the gap so that construction is possible from both banks simultaneously. Once the materials and personnel are across and the main cables are in place, dismantle the cableway and the wire rope that were used as guy lines, if necessary. Refer to *FM 5-125* for more information on installing cableways.

LEVEL SILL AREAS

10-74. After marking the sites for the towers, level the sills. If footings are needed, make the sill area large enough to accommodate the forms. As the sills are being prepared, assemble the towers and fabricate the deadmen. Erect the towers and install the side and back braces.

PLACE MAIN CABLES

10-75. Attach a lead line to the main cable and carry the lead line to the other side of the gap. If the main cables are on reels, place the reels behind the tower and pull the cables over the tower, across the gap, and over the far tower. Temporarily clip the cable ends around the deadmen. Use a ratchet chain hoist to set the cable to the proper sag configuration. When the cable is properly seated, set and tighten the clips.

CONSTRUCT AND INSTALL HANGERS

10-76. Assemble the floor beams, posts, knee braces, and suspenders to form the hangers. After assembling the posts, braces, and beams, wrap the suspenders around the floor beams and clip them. Notch the floor beam so that the suspender does not have to bend sharply. Measure the effective length of the suspenders, install a thimble, and clip the suspenders onto the main cables. Do not tighten the clips until the stringers are placed. Recheck the effective length after completing the bridge. Use a scaffold when placing the hangers. Place the hangers simultaneously from each end of the bridge.

INSTALL STRINGERS

10-77. When the first hanger is positioned, place and connect the stringers to the sill and the floor beams. Ensure that the suspenders are vertical and then tighten the clips. Repeat the process with the next hanger. Nail cleats to the undersides of the stringers to keep them in place on the floor beams.

INSTALL SWAY BRACING AND FLOOR PLANKS

10-78. If using timber sway bracing, nail it in place before installing the floor planks. Place the bracing diagonally and nail it in place, and then install the floor planks. If using wire bracing, place the frame first, leaving out the planks so that the wires can be installed. Tighten the wires with rack sticks, and install the remaining floor planks to hold the rack sticks in place.

INSTALL SIDE RAILS AND CURBS

10-79. After completing the floor, install the side rails and the toeboards or curbs. Make splices 2 to 3 feet from the side-rail posts. Use splice plates on all splices. Install saw-tooth bracing after installing the side rails and curbs.

RECHECK CABLE CONNECTIONS

10-80. Ensure that all suspenders are vertical and that all cable connections are secure. Test the bridge with light loads before allowing the heavier loads (up to the rated capacity) to cross the bridge.